I. C. 6200

December, 1929

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BY

W. F. HAZEN AND E. J. CHRISTY

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METHOD AND COST OF MINING THE PITTSBURGH, OR NO. 8, COAL BED IN A 100 PER CENT MECHANIZED MINE IN EASTERN OHIO[1]

By W. F. Hazen[2] and E. J. Christy[2]

INTRODUCTION

This paper describing the mining practices at a 100 per cent mechanized mine working the Pittsburgh or No. 8 coal bed in eastern Ohio is one of a series being prepared by the U. S. Bureau of Mines on mining practices, methods, and costs in the various mining districts of the United States. The purpose of assembling this data is to place before those interested in the mining industry the methods employed and the cost data on the items involved in the winning of the coal and its removal to the railroad car at the tipple.

Mining costs are governed by the mining method used, which is selected for its adaptability to local natural physical conditions such as the nature and thickness of the coal, its dip, the character of the roof and floor, and the thickness of the overlying strata.

This circular presents a detailed description of the mining method employed, the equipment used, and the results obtained in a mine 100 per cent mechanically operated and developed in the Pittsburgh or No. 8 coal bed in eastern Ohio. The mine supplies the parent company with fuel and is classed as a "captive" mine.

An uninterrupted supply of clean coal is one of the stipulations of the parent company, and to ensure a high efficiency the mine operates two shifts of eight hours each day with time between shifts for servicing the mechanical equipment and taking in supplies.

HISTORY

The mine under discussion has been owned and operated by the present company since the latter part of 1919, and up to the time of this report has produced 2,330,559 tons of coal. When acquired by the present company the mine had been operating for several years and was purchased as a fully-equipped and operating mine; therefore, the quality and character of the coal was well known and established.

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1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used "Reprinted from U. S. Bureau of Mines Information Circular 6200."

2 - One of the consulting engineers, U. S. Bureau of Mines.

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From the opening of this mine until the middle of 1925 all coal was undercut by machines, loaded by hand, and gathered by mules. At this time a mechanical loading machine was put in operation and a gathering locomotive was used for collecting the coal. An electric drill was used for making shot-holes, to replace the hand auger formerly employed for this purpose. In January, 1927, another mechanical loading, gathering, and drilling unit was added, and the experiment of mechanizing the mine was continued. Daily time studies of the operations were kept until April, 1927, when the mine was closed because of the expiration of the union contract. About this time the management determined to adopt methods to prevent periodic shutdowns, and after carefully considering the records and time studies of the mechanical loaders, it was decided to adopt plans for 100 per cent mechanical operation.

Through delays and various other causes it was March 1, 1928, before everything was ready for the production of coal to be resumed on a "wage payment on unit plan," working double shift five and a half days each week, the entire production being mechanically cut, drilled, loaded, and hauled.

GEOLOGY AND TOPOGRAPHY

Figure 1 shows typical sections of the geologic measures. The rocks are embraced in the Monongahela series of the Carboniferous system and are composed of shales, sandstones, several thick beds of limestone, and the Pittsburgh or No. 8 coal bed, the lowest member of the group. Another bed of coal 3 to 4 feet thick, which is locally termed the meigs coal, is occasionally found near the hilltops about 85 feet above the No. 8 bed and is being worked locally at several small mines for domestic purposes only. From 16 to 25 feet above the No. 8 bed is a bed of shale and coal about 12 inches thick, which may be what is termed the Pomeroy coal in other sections of this field.

From 5 to 7 feet above No. 8 bed is limestone 12 to 15 feet thick, about 4 feet of shale, bony, and coal, and then another bed of limestone 24 to 27 feet thick. Due to the difficulty which may be encountered in breaking or controlling these two members, no attempt has been made to recover pillars between rooms in the district. The elevation at the mouth of the mine is 1,050 feet above sea level

The district is a plateau area dissected by shallow valleys, offering easy access by drifts to the coal bed which outcrops on the hillsides.

CHARACTER OF COAL BED AND OVERBURDEN

Figure 2 shows detailed sections of the Pittsburgh or No. 8 coal bed worked at this mine. The bed averages 54 to 59 inches in thickness and is made up of three distinct benches. The bottom bench is fairly uniform and is 29 to 29-1/2 inches thick; above this bench is a 1/2-inch slate binder, on top of which is a bony coal that is 1-1/2 to 2 inches thick and corresponds with the bearing-in bench usually found in the Pittsburgh or No. 8 coal bed. Over this bearing-in bench is a binder one-half inch thick, above which is the breast coal which varies from 23 to 26 inches in thickness. The coal is fairly hard in structure and breaks in cubical blocks with a bright luster.

The distinguishing features of the Pittsburgh or No. 8 bed are its bearing-in bed

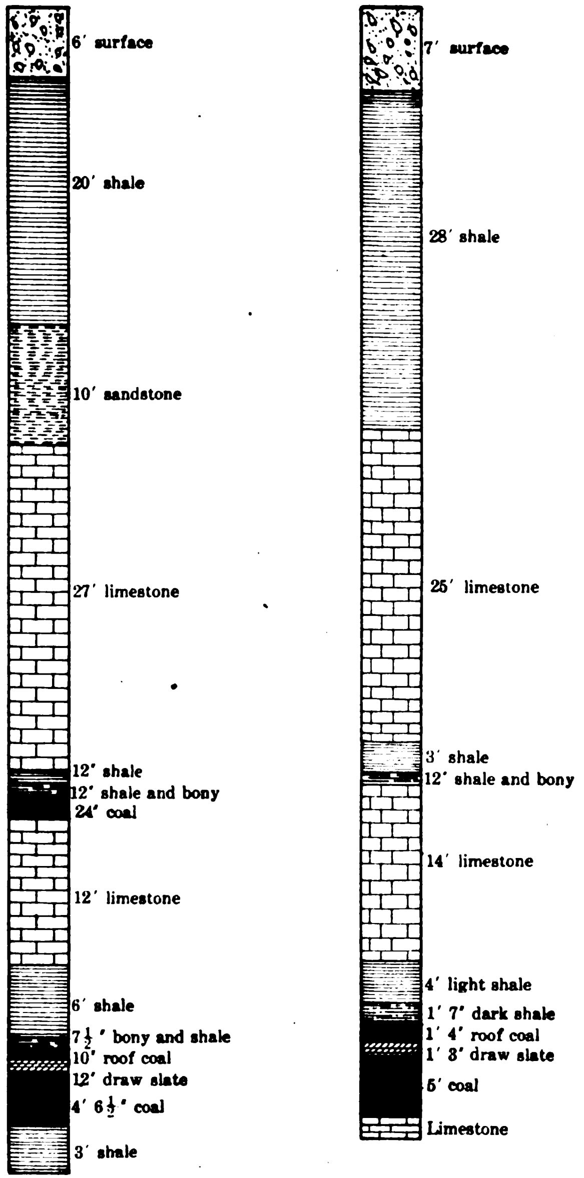

Figure 1.- Log of two of six diamond-drill holes, giving geological sections of the Monongahela group

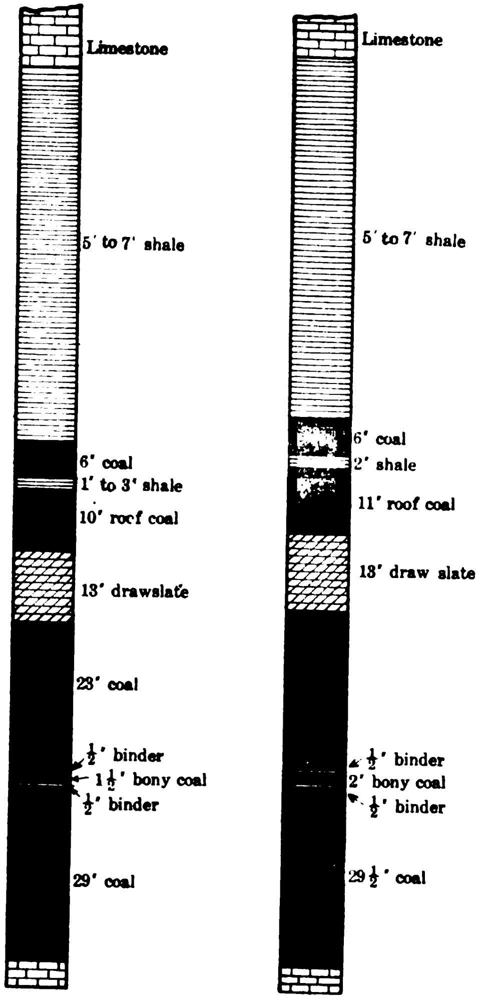

Figure 2.- Typical cross sections of the Pittsburgh, or No. 8, coal bed and immediate roof

and binders and the pronounced face slips which run about S. 74° E. The butt slips run at an angle of 90° with the face slips and are not so pronounced.

Immediate Roof.- Immediately above the coal bed is the draw slate which is about 13 inches thick all over the mine, due to the method of blasting employed, this draw slate stays in place until the coal has been loaded out, then it has to be blasted to bring it down.

Above the draw slate is the roof coal which varies from 17 to 19 inches in thickness and which includes a shale parting varying from 1 to 3 inches in thickness 6 inches from the top. Where this shale thickens to 3 inches or more the roof coal is held with difficulty.

Above the roof coal is a treacherous soft shale 5 to 7 feet thick which presents a difficult and expensive roof problem on account of its ready disintegration whenever exposed to the air.

Below the coal is a bed of limestone and shale 18 to 36 inches thick. The floor is hard and shows no signs of heaving.

Cover.- The cover over the coal bed varies from a few feet at the outcrop to a maximum of 200 feet under the highest points of the hills, with an average of approximately 100 feet all over the mine.

Faults.- There are no displacement faults in the coal; clay veins have been encountered, but not frequently enough to constitute a mining problem. Rolls are rarely encountered, although one was struck on the main haulageway which caused the grade to be 2-1/2 per cent against the load so that it was necessary to "brush" 1,400 feet of entry to reduce the grade to 0.5 per cent against the load. The normal dip of the coal bed is 26 feet to the mile, due south.

Water.- As a small amount of water is encountered at all places, the mine may be termed damp; but as the water finds easy access to the surface, no unusual problems are encountered. The water, however, has a decided acid reaction.

Gas.- Due to light cover and outcrop workings no gas has been found in this mine, though frequent tests are made with a flame safety lamp; the mine is termed nongassy.

Prospecting, Exploration, and Sampling.- As already stated, the mine was acquired when fully equipped and operating; therefore the character of the coal was well known. However, since acquiring the property the present operators have put down six diamond-drill holes whose findings are checking closely with the present underground development. An average analysis of the coal as shipped is as follows:

Constituent	Per cent
Moisture	2.2
Volatile matter (dry coal)	36.6
Fixed carbon	52.4
Ash	11.0
	100.0
Sulphur	3.3
B.t.u.	12870

METHODS OF DEVELOPMENT AND MINING

As the coal crops out on the hillside, the mine is opened by a drift, and the coal is delivered to the tipple by electric locomotives.

Tipple.- The tipple and preparation plant is of steel construction, covered with zinc-coated corrugated iron. It is equipped with car stops, cross-over dump, shaker screens, crusher, and picking tables for sizing, cleaning, and preparing the product for fuel to meet the requirements of the parent company.

Method of Development.- The general plan of development has been on the room-and-pillar panel method, which is characteristic of this district (fig. 3). Two entries were driven from the surface on 50-foot centers for a distance of 600 feet, then a third entry was broken off, the centers were changed to 30 feet, and rooms were turned off the third or west entry; about 2,800 feet from the mouth of the mine the fourth entry was added, thus making a set of four main face entries to develop the major part of the property. From a point about 1,300 feet from the mouth of the mine barrier pillars 150 feet thick are left for protection of the face entries, and pairs of butt entries are turned on either side 400 feet apart. From these butt entries, rooms 26 feet wide on 32-foot centers are turned in blocks of five rooms as the entries advance, leaving a solid block of coal between each set of rooms. While the rooms are being worked their distance of 200 feet, the entries are advanced and rooms necked so that when the first block of rooms is worked out the next block is all ready to go, thus ensuring a uniform tonnage and number of working places on each entry. When the rooms have been driven the required length, the track material and about 50 per cent of the posts are recovered, and the room is allowed to cave.

Because of the treacherous slate above the roof coal and the difficulty with which the two beds of limestone above the shale are broken or controlled, no attempt is made to recover room or butt entry pillars. It is planned to recover a part of the barrier pillars by driving butt rooms on the regular room centers.

The company engineer estimates that 55 per cent of the coal is extracted under the present system of mining.

As has been previously mentioned, the officials of this company have worked out an unusual method of distributing the work and of developing and operating the mine on what is known as the wage payment on unit plan.

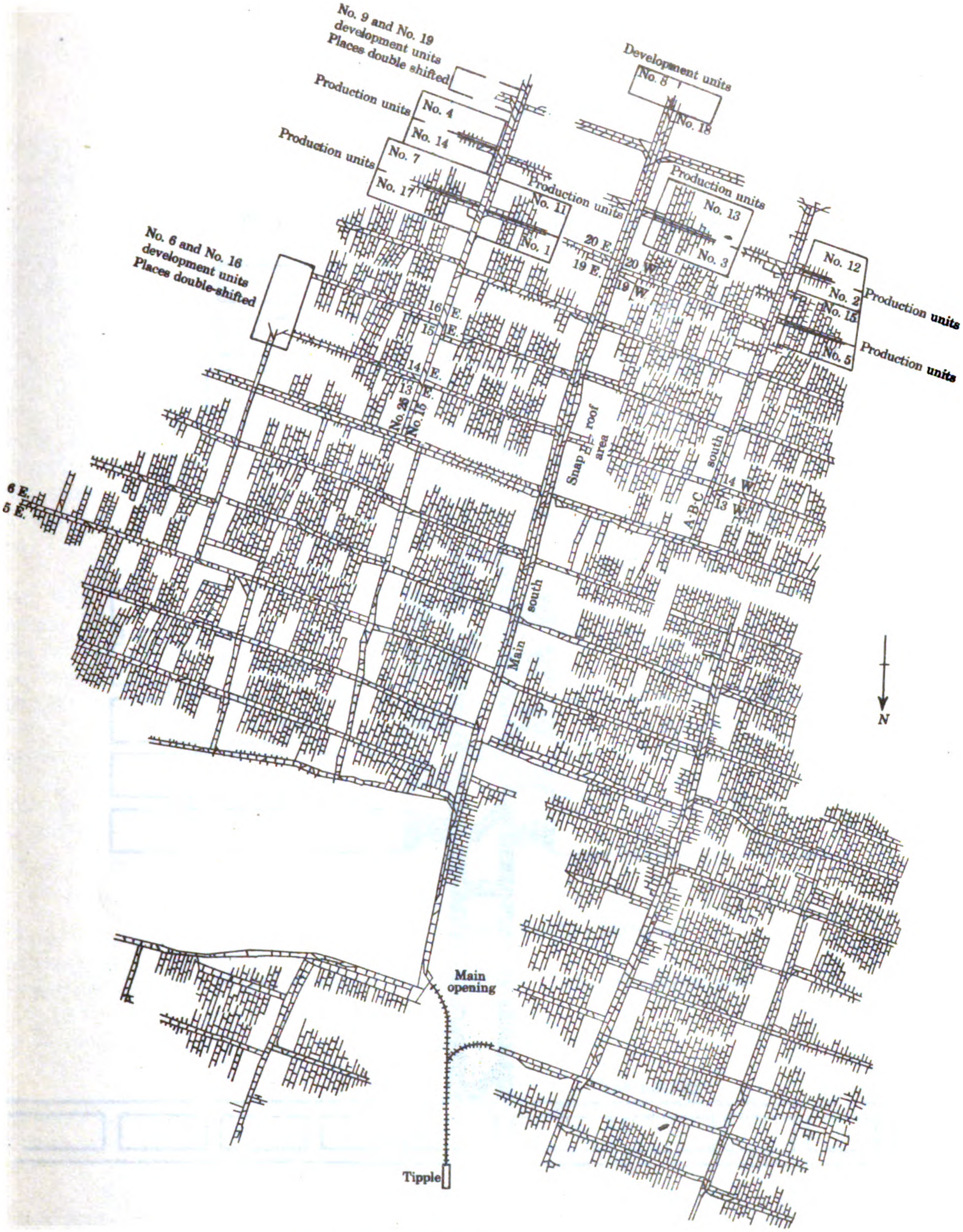

Figure 3. – Plan of mine development

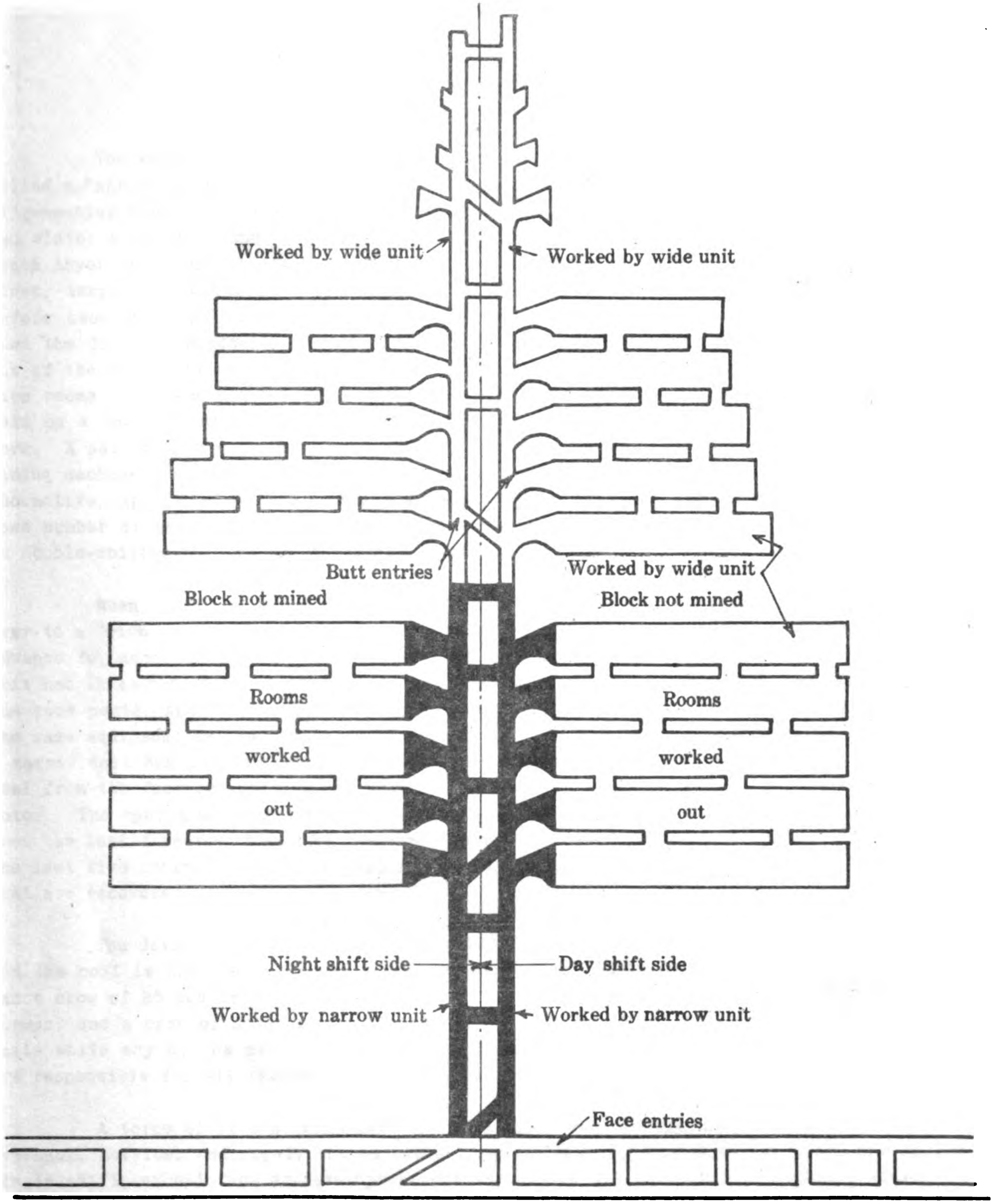

Figure 4.- After reaching this stage, the section is turned over to "wide units" who work the rooms and complete the development of the entries

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The work of developing a pair of butt entries is performed by a crew of nine men called a "narrow unit." The crew consists of a loading-machine operator and helper; a cutting-machine operator and helper, who also drill all the shot holes for blasting the coal and slate; a motorman and trip rider who trims the cars during the loading operation; one track layer who lays all the track and switches; one shot firer who handles all the explosives, tamps and shoots the coal and draw slate, scrapes all the cuttings from the kerf before shooting, and helps drill shot holes when necessary; and one stoneman who takes down the draw slate after the coal has been loaded out and helps load it or throw it back out of the way. This narrow unit or crew proceeds with the development of the entry until five rooms have been necked. The crew is paid on the narrow-unit bases - all members are paid on a tonnage rate, established from the base rate of pay for the several classes of work. A narrow-unit crew has the following equipment: One loading machine, one shortwall mining machine, one electric drill for drilling shot holes, one 4-ton cable-reel gathering locomotive, and 16 mine cars. The night-shift unit uses the same equipment and has the same number of men to develop the parallel entry and the rooms off it, thus the equipment is double-shifted but not the territory. (See fig. 4.)

When a pair of butts has been developed for five room lengths, the area is turned over to a "wide unit" who work the five rooms and drive the entry, necking the rooms as they advance for another block of five rooms; this crew is paid on the wide-unit basis. A wide unit has three men in addition to those employed in a narrow unit - a timberman who sets all the room posts, and two extra slatemen who throw the draw slate back in the gob - and has the same equipment as the narrow unit, except that 27 mine cars are assigned to it, whereas a narrow unit has only 16 cars. The wide unit does all the work pertaining to taking the coal from the face and putting the cars on the parting to be picked up by the main-haulage motor. The operating crew recovers all the track in the rooms as the entry advances, and when the last five-room block is finished the crew proceeds to the next entry; the track in the last five rooms is then recovered by the maintenance crew, who also pulls all the posts that are recovered.

The development of face entries is carried on double shift on a narrow-unit basis, and the coal is charged to separate unit accounts. In addition to these units, a maintenance crew of 25 men is employed on both shifts and is composed of motormen, pumpers, timbermen, and a crew of seven men known as the "flying squadron" who fill in on the various units while any of the members are absent. There are also two foremen on each shift who are responsible for all the operations in their respective districts.

A force of 12 men, mechanics and repairmen, are employed for the two shifts; they overhaul, service, and repair the mechanical equipment. By this plan two mines are worked single shift, except face or development entries, while all equipment is double-shifted.

Mining.- All of the coal produced is undercut by electrically driven shortwall mining machines equipped with 6-foot cutter bars. There are 9 machines, and all are worked double shift, one for each unit.

Table 1 gives the daily average tonnage produced, the average number of tons per shift, number of shifts worked, and the total coal produced during February, 1929, by each of the 18 units 12 of which are wide units and 6 are narrow units. There were 20 full working days and four half days or Saturdays during that month. The equipment on each unit was as follows: 1 mechanical loading machine, 1 cutting machine, 1 electric drill, 1 gathering locomotive, 27 mine cars for a wide unit, and 16 mine cars for a narrow unit.

Table 1.- Time worked and coal mined during February, 1929

Unit No.	Machine No.	Shift	Period	Total tons produced	Average daily tonnage
1	1	Day	1 - 15	1,599.05	133.25
1	1	Day	16 - 28	1,497.80	149.78
			1 - 28	3,096.85	140.76
11	1	Night	1 - 15	1,579.25	131.60
11	1	Night	16 - 28	1,386.55	138.65
			1 - 28	2,965.80	134.81
Total coal cut by No.1 machine, tons				6,062.65	275.57
2	2	Day	1 - 15	1,324.50	110.37
2	2	Day	16 - 28	1,258.10	125.81
			1 - 28	2,582.60	117.30
12	2	Night	1 - 15	1,587.10	132.25
12	2	Night	16 - 28	1,343.70	134.37
			1 - 28	2,930.80	133.22
Total coal cut by No.2 machine, tons				5,513.40	250.61
3	3	Day	1 - 15	1,498.10	124.84
3	3	Day	16 - 28	1,265.80	126.58
			1 - 28	2,763.90	125.63
13	3	Night	1 - 15	1,507.90	125.65
13	3	Night	16 - 28	1,243.00	124.30
			1 - 28	2,750.90	125.05
Total coal cut by No.3 machine, tons				5,514.80	250.67
4	4	Day	1 - 15	1,565.10	130.42
4	4	Day	16 - 28	1,218.20	121.82
			1 - 28	2,783.30	126.51
14	4	Night	1 - 15	1,639.25	136.60
14	4	Night	16 - 28	1,492.50	149.25
			1 - 28	3,131.75	142.35
Total coal cut by No 4 machine, tons				5,915.05	268.86

Table 1.- Time worked and coal mined during February, 1929 - Continued

Unit No.	Machine No.	Shift	Period	Total tons produced	Average daily tonnage
5	5	Day	1 - 15	1,828.55	152.37
5	5	Day	16 - 28	1,357.20	135.72
			1 - 28	3,185.75	144.81
15	5	Night	1 - 15	1,596.90	133.07
15	5	Night	16 - 28	1,285.35	128.53
			1 - 28	2,882.25	131.01
Total coal cut by No.5 machine, tons				6,068.00	275.82
Narrow Unit					
6	6	Day	1 - 15	754.95	62.91
6	6	Day	16 - 28	702.40	70.24
			1 - 28	1,457.35	66.28
16	6	Night	1 - 15	835.95	69.66
16	6	Night	16 - 28	761.85	76.18
			1 - 28	1,597.80	72.63
Total coal cut by No.6 machine, tons				3,055.15	138.87
7	7	Day	1 - 15	1,288.00	107.35
7	7	Day	16 - 28	1,130.30	113.03
			1 - 28	2,418.30	109.92
17	7	Night	1 - 15	1,556.55	129.71
17	7	Night	16 - 28	1,250.85	125.08
			1 - 28	2,807.40	127.61
Total coal cut by No.7 machine, tons				5,225.70	237.53
Narrow Unit					
8	8	Day	1 - 15	791.30	65.94
8	8	Day	16 - 28	761.70	76.17
			1 - 28	1,553.00	70.59
18	8	Night	1 - 15	885.45	73.78
18	8	Night	16 - 28	792.80	79.28
			1 - 28	1,678.25	76.28
Total coal cut by No.8 machine, tons				3,231.25	146.87
Narrow Unit					
9	9	Day	1 - 15	845.95	70.49
9	9	Day	16 - 28	806.65	80.66
			1 - 28	1,652.60	75.12
19	9	Night	1 - 15	972.20	81.01
19	9	Night	16 - 28	872.65	87.26
			1 - 28	1,844.85	83.86
Total coal cut by No.9 machine, tons				3,497.45	159.97

The foregoing table shows that 34,299.60 tons of coal was produced from wide units by six mining machines, a daily average of 259.84 tons per machine, and 9,783.85 tons from narrow units by three mining machines, a daily average of 148.24 tons per machine, or a total production of 44,083.45 tons, a daily average for nine machines of 222.64 tons per machine.

Drilling and Blasting.- The shot holes for breaking down the coal and draw slate are drilled by the machinemen, sometimes assisted by the shot firer, who use a small unmounted electric drill. The auger used is 6 feet long and is sharpened like a regular coal auger with only one cutting edge.

In rooms five shot holes are used in the coal and three in the draw slate. Each group of holes are drilled on the same level and 4 to 6 inches shorter than the kerf, as shown in Figure 5. The shot hole fired first is No. 1, which is placed just above or below the binder of the "bearing-in bench"; three sticks of explosive are used. The next shots fired are the two lifters, which are drilled about 8 feet from each rib, 12 inches below the draw slate, and with a slight incline toward the center of the face; two sticks of explosive are used in these shots. The two rib shots are fired next; these holes are drilled about 2 feet from each rib, 9 inches below the draw slate, and are slightly inclined toward the corners of the face to insure breaking the corners down. All of these shot holes are drilled as near level as possible.

When the coal has been loaded out of the rooms the draw slate is shot down; three shot holes are drilled for this purpose, one about in the center of the face and one about 4 feet from each rib, slightly inclined to the corners; one-half of a stick of black pellet powder is used in each hole.

In the entries three shot holes are drilled in the coal and two in the draw slate. One shot hole, in which four sticks of explosive are used, is placed in the center just above or just below the binders; this shot is fired first. The two rib holes are drilled 18 to 24 inches from the rib, slightly inclined to the corners, 9 to 12 inches below the draw slate, and as nearly level as possible; three sticks of explosive are used in each hole.

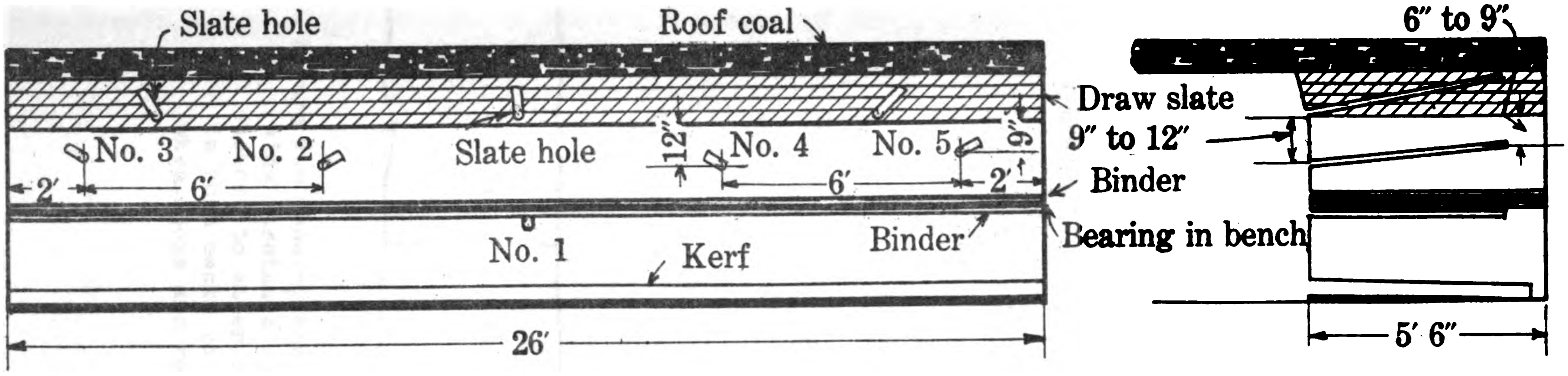
When the coal is loaded in the entries the draw slate is shot down by firing two holes placed about 3 feet from each rib, slightly inclined to the corners and upward to the roof; one-half of a stick of black pellet powder is used in each of these holes.

Before shooting, the cuttings are scraped from the kerf by the shot firer, who loads, tamps, and shoots all shot holes electrically.

During the period May 1, 1928, to April 30, 1929, 97,718 pounds of explosive was used to produce 477,273.10 tons of coal, equivalent to 4.88 tons of coal per pound of explosive used.

Rooms.- Room necks 13 feet wide are turned off the butt entries on 32-foot centers for a distance of two cuts or 11 feet, as shown in Figure 6, and are then widened out fan-

Position of shot holes in rooms



Position of shot holes in entries

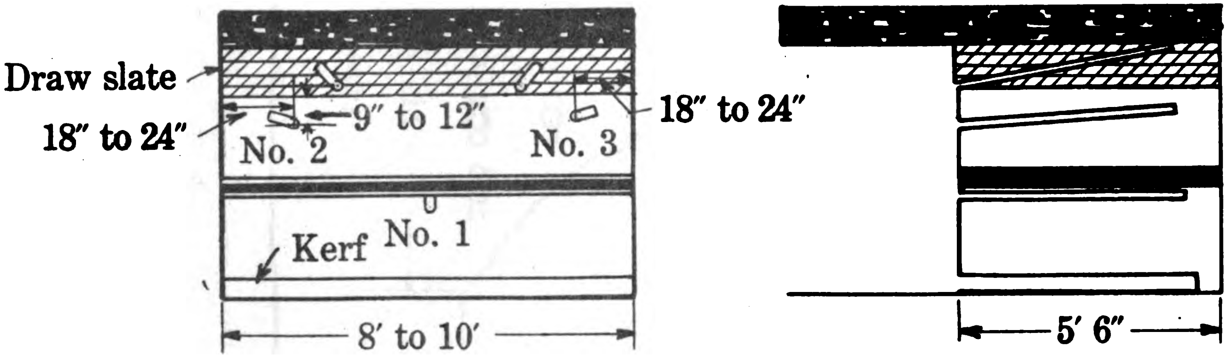


Figure 5.-Position of shot holes for blasting.
The shot holes are fired in the order of the number of the hole.
Shot holes in the draw slate are fired after the coal is loaded out

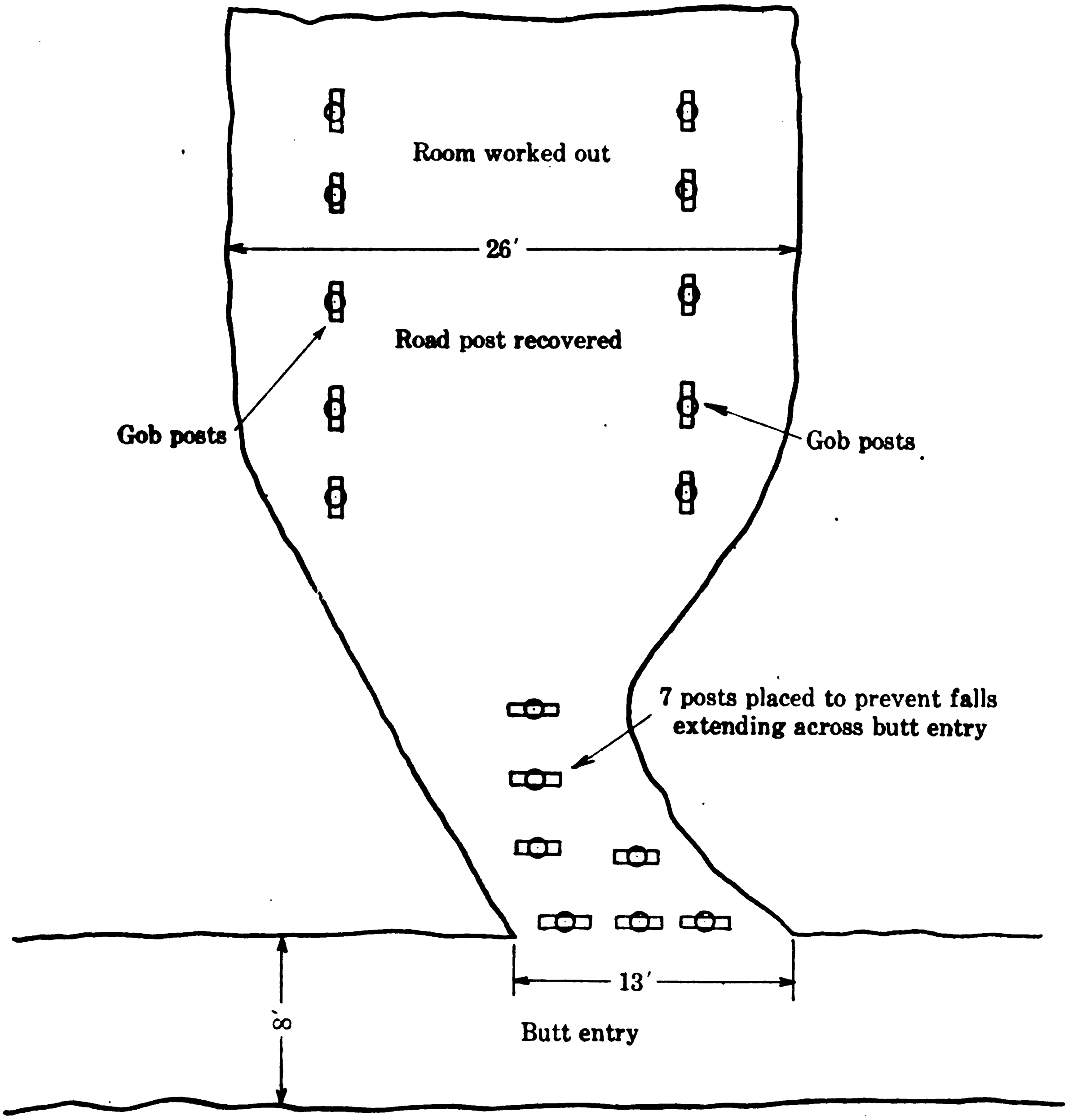


Figure 6.- Showing how room necks are turned to avoid excessively wide stretches and at the same time to allow the mechanical loader to enter the room with ease. The method of posting in room necks to prevent falls extending to the butt entries when rooms are worked out is also shown

wise to a width of 26 feet on the face slips. This leaves a pillar 6 feet thick between rooms, which are driven a distance of 200 feet from the butt entry; at this distance the rooms connect with the room from the adjoining butt entry. The track is laid 9 inches off the center of the room.

When the rooms have been driven the required distance of 200 feet, the track material and about 50 per cent of the posts are recovered, and the roof is allowed to cave.

Entries.- Entries 8 feet wide are advanced on the face slips for face entries and on the butt slips for butt or room entries. The face or main entries are double-shifted and are worked by a narrow unit consisting of nine men who perform all the work of cutting, blasting, mechanical loading, and placing the coal on the pass-by to be picked up by the main-haulage motor. This crew of men is paid on a narrow-unit basis.

After the development period is reached on the butt entries, the work of advancing the rooms and one butt entry is turned over to a wide unit, who must advance the entry the distance of the next five rooms and turn the room necks as the advance is made. This work is paid for on a wide-unit basis.

The extra compensation which is generally paid in coal mines in the form of yardage is covered at this property in the wage payment plan on unit basis.

Loading.- All coal at this mine since March 1, 1928, has been mechanically loaded by electrically driven machines, nine of which are in operation; all are double-shifted, and excepting in face entries they do not work in the same territory. Each shift or unit has its own district. During February, 1929, 44,083 tons of coal was loaded, a daily average of 222.64 tons per machine. The wide units loaded a daily average of 259.84 tons per machine and the narrow units a daily average of 148.24 tons. (For a detailed production record of all units see Table 1.)

Deadwork.- The principal items under the head of deadwork that influence the mining cost are the difference paid between the narrow and wide units in the wage payment plan on unit basis, the cleaning of falls on haulage and airways, and the hauling and disposal of slate on the surface.

The items of deadwork necessary for each unit to perform which are included in the unit rate are blasting, cleaning the coal of impurities, and laying all track, including switches, in the district. This also involves the care of the roof and its support, which is general practice in the district.

Timbering.- The immediate roof is the stratum of roof coal immediately above the draw slate. When this is held, it forms a good roof in rooms and butt entries which are not of long life, but in face entries which have been open for some time it is difficult to hold without extensive support. This support is furnished in the shape of 6, 8, and 10 inch I-beams, lengths of 60-pound T-rails, and wooden crossbars 8 to 10 inches in diameter. These roof supports or crossbars are placed on short blocks which rest on the coal, as in

Figure 7. Tight lagging of split posts is used for practically all entry roof support.

The main haulageway has been coated for a distance of 1,400 feet with about 3/4-inch layer of gunite to eliminate the necessity of roof supports. This work has been completed for more than a year, is standing well, and seems to be doing the work intended for it.

No rules for a definite system of posting in rooms have been adopted. However, the general plan as shown in Figure 8 is to use four rows of posts in rooms 26 feet wide. The road posts are placed 20 to 24 inches on either side of the track and 4 to 5 feet apart. A row of gob posts is used on each side about 4 feet from the road posts and 4 to 5 feet apart. When the room is worked out, most of the road posts are recovered. Cap pieces 6 inches wide, 12 inches long, and 1 to 2 inches thick are used on all posts. When the face is cut the two rows of road posts are placed within 4 to 5 feet of the face before shooting. When the rooms are worked out, seven posts are placed in the room neck with large cap pieces, as shown in Figure 6.

During the period May 1 to December 31, 1928, when 297,347 tons of coal was produced, the following timber was used for roof support: 64,243 posts, equal to 385,458 linear feet and 4.63 tons of coal per post, and 0.7714 ton per linear foot of posts; also 80,844 cap pieces equal to 3.68 tons of coal each.

Haulage.- Mine tracks, size of trip, and equipment have been standardized. The track gage is 42 inches. On the main haulageway 60-pound rail is laid on 4 by 6 inch by 5 foot oak ties on 18-inch centers; on the secondary haulageways 40-pound rail is laid on 4 by 6 inch by 5 foot oak ties on 24-inch centers. The standard radii of curves and switches on main and secondary haulage tracks are 112 feet for No. 4 frogs and 63 feet for No. 3 frogs.

In the butt entries and rooms 25-pound rail with ties on 24-inch centers are used with a No. 1-3/4 frog for room turnouts on a radius of 21 feet.

Cars are delivered to and from the loading machine at the face by an electric gathering locomotive, the motorman and trip rider being paid on a tonnage basis calculated from the standard base rate of pay for that class of work.

Tables 2 and 3 give detail of the work accomplished on the main and secondary haulage. During February, 1929, 44,083.45 tons was produced, 21,493.65 tons of which was produced on the day shift, with an average daily tonnage of 976.98 tons. The average weight of coal in the car was 3.06 tons; the weight of the empty car is 1.88 tons. The length of main haul is 0.87 mile, and 41,686.20 ton-miles of work was accomplished, or 1.9395 ton-miles of work on the main haulage per ton of coal produced in 22 full 8-hour shifts.

On the night shift 22,589.80 tons of coal was produced with a daily average of 1,026 81 tons. The average weight of coal in the car was 3.12 tons The length of haul was 0.87 mile and weight of empty car was 1.88 tons; 43,353.15 ton-miles of work was accomplished, or 1.9191 ton-miles of work on the main haulage per ton of coal produced in 22 full 8-hour shifts. One 15-ton locomotive was employed on each shift.

On the secondary haulage the average length of haul is 0.63 mile; during the same period 62,104.20 ton-miles of work was accomplished: 30,521.49 ton-miles on the day shift hauling 21,493.65 tons of coal, and 31,582.71 on the night shift hauling 22,589.80 tons of coal, or 1.4087 ton-miles of work on the secondary haulage for each ton of coal produced.

On the gathering haulage the coal is taken from the mechanical loader at the face by cable-reel gathering locomotives. One locomotive serves the loader in each unit and deposits it on the side track at the mouth of the butt entry where it is picked up by the secondary haulage motor. A detail of cars hauled and tons produced is given in Table 2.

Table 2.- Work of one 15-ton main-haulage locomotive on two 8-hour shifts during February, 1929

Item	Day shift	Night shift
Shifts worked	22	22
Cars hauled	7,027	7,240
Coal, tons	21,493.65	22,589.80
Average coal per shift, tons	976.98	1,026.81
Average coal in car, tons	3.06	3.12
Weight of empty car, tons	1.88	1.88
Distance hauled, mile	0.87	0.87
Work done in hauling coal, ton-miles	18,699.48	19,663.13
Work done in hauling car, ton-miles	22,986.72	23,690.03
Total work in haulage, ton-miles	41,686.20	43,353.15
Work done per ton of coal produced, ton-miles	1.9395	1.9191

Table 3.- Secondary haulage, 1 to 15-ton locomotive, February, 1929
Average weight with coal 3.09 tons
Weight empty 1.88

	Shift	Length of haul, mile	Cars	Tons produced	Ton-miles coal	Ton-miles empty	Total ton-miles of work
No. 1 unit	Day	0.63	982	3,096.85	1,952.02	2,326.16	4,278.18
No. 11 unit	Night	0.63	933	2,965.80	1,868.45	2,110.09	3,978.54
No. 2 unit	Day	0.68	783	2,582.60	1,756.16	2,000.61	3,756.77
No. 12 unit	Night	0.68	910	2,930.80	1,992.94	2,326.68	4,319.62
No. 3 unit	Day	0.51	912	2,763.90	1,494.70	1,748.85	3,243.55
No. 13 unit	Night	0.51	896	2,750.90	1,402.95	1,718.06	3,121.01
No. 4 unit	Day	0.70	898	2,783.30	1,948.31	2,363.53	4,311.84
No. 14 unit	Night	0.70	1,018	3,131.75	2,192.22	2,679.37	4,871.59
No. 5 unit	Day	0.63	1,049	3,185.75	2,007.02	2,484.87	4,491.89
No. 15 unit	Night	0.63	934	2,882.25	1,815.81	2,212.45	4,028.26
No. 6 unit (Narrow)	Day	0.53	485	1,457.35	772.39	966.50	1,738.89
No. 16 unit (Narrow)	Night	0.53	511	1,597.80	846.83	1,018.32	1,865.15
No. 7 unit	Day	0.64	794	2,418.30	1,547.71	1,910.68	3,458.39
No. 17 unit	Night	0.64	906	2,807.40	1,796.73	2,180.19	3,976.92
No. 8 unit (Narrow)	Day	0.63	505	1,553.00	978.49	1,196.24	2,174.73
No. 18 unit (Narrow)	Night	0.63	534	1,678.25	1,057.29	1,276.27	2,333.56
No. 9 unit (Narrow)	Day	0.76	630	1,652.97	1,265.97	1,801.28	3,067.25
No. 19 unit (Narrow)	Night	0.76	590	1,844.85	1,402.08	1,685.98	3,088.06
Total	-	-	-	44,083.45	28,098.07	34,006.13	62,104.20

Mine Cars.- The cars used are of steel with wooden bottoms, equipped with end gates, 16-inch wheels with Timken bearings, and ratchet brakes; they have a capacity of 102 cubic feet. During February, 1929, 14,269 cars were dumped at the tipple; these contained 44,083.45 tons of coal, an average load of 3.09 tons for each car. There are 212 of these mine cars, and each car was loaded average of 1.53 times each shift for the 44 shifts of the period.

Drainage and Pumps.- As previously stated, this mine may be termed damp, as a little water is encountered everywhere. Three 35-gallon gathering pumps drain the water into a sump near the main haulage, from which point it is carried to the surface by a 6 by 8 inch wood pump having a capacity of 125 gallons per minute The water is acidic

Ventilation.- The ventilation is supplied by a 5-foot fan belt driven by a 75-horsepower electric motor, blowing 50,000 cubic feet a minute against a 2-inch water gage.

Single board stoppings are used in crosscuts, so that the air is conducted around the mine in a continuous current. Doors are built of lumber and are hung to close with the air current.

Work is about to be commenced on an air shaft near the present working-face headings; this air shaft is expected to solve the ventilation problems at this mine.

Power, Kind, and Voltage.- At the mine the power furnished by a public utility company in 4,000 and 2,300 volts a.c. units in converted into 250 d.c., which is the pressure used on all underground equipment. During February, 1929, 158,228 kilowatt-hours of power was consumed at the mine to produce 44,083.45 tons of coal, thus 3.59 kilowatt-hours was consumed per ton of coal produced.

Wage Payment Unit Plan.- Table 4 gives the scale of wages used. The wage payment on a unit basis plan provides that all the work performed is taking the coal from the face and placing it on the side track to be picked up by the secondary haulage be paid on a tonnage basis. A base rate of pay for an 8-hour day or shift was established; then a tonnage rate was calculated for development, or a narrow unit, so that it would equal the base rate when 70 tons was produced. A narrow unit is composed of nine men: a mechanical-loader operator, mechanical-loader's helper, cutting-machine runner, cutting-machine helper (the cutting machine men with the assistance of the shot firer drill all shot holes), a shot firer, tracklayer, motorman, trip rider, and stoneman.

A wide-unit base rate for an 8-hour day is the same as the narrow-unit rate, but the tonnage rate is based on a production of 125 tons. The organization of a wide unit is the same as that of a narrow unit, with the addition of a timberman, who sets all posts in rooms, and two more stonemen, making a crew of 12 men.

When any member of a unit is absent from work, a man is taken from the replacement or flying squadron to fill his place; this man, for the period he is working in a unit, is paid on the tonnage rate for the class of labor performed.

The company furnishes all tools and explosives used by the various units.

Supervising officials are paid on a monthly basis, and no bonus in addition to the regular wage scale is paid. Eight hours constitutes a day's work, and while the tonnage rate has been calculated from the daily base rate, using 125 tons for a wide unit and 70 tons for a narrow unit, no limit is placed on the amount of coal that may be produced.

Table 4.- Scale of wages under the wage payment on unit basis

Class of labor	Base rate, 8-hour day	Wide unit per ton	Narrow unit per ton
Mechanical-loader operator	$8.00	0.064	0.114
Mechanical-loader helper	7.00	0.056	0.10
Cutting-machine runner	7.50	0.06	0.107
Cutting-machine helper	7.50	0.06	0.107
Shot firer	6.25	0.05	0.089
Track layer	6.25	0.05	0.089
Timbermen	6.25	0.05	0.089
Motormen	6.25	0.05	0.089
Trip rider	6.25	0.05	0.089
Stonemen	6.25	0.05	0.089

Maintenance	Per month	Per day
Inside:		
Foremen	$267.00	-
Repairmen	185.00	-
Motormen	-	6.14
Trip riders	-	6.14
Track layers	-	6.14
Bratticemen	-	6.14
Pumpers	-	6.14
Wiremen	-	6.14
Laborers	-	6.14
Outside:		
Shop foreman	$250.00	-
Substation man	185.00	-
Blacksmith	-	6.24
Carpenter	-	5.92
Car repairers	-	5.92
Watchman	-	5.56
Outside laborers	-	5.56

SUMMARY OF COSTS

Coal Mined During February, 1929.- During February, 1929, which has been selected as a typical month for the purpose of arriving at the following cost percentages, 44,083.45 tons of coal was mined during 44 full 8-hour shifts: 22 day shifts and 22 night shifts. Table 5 gives the material and labor costs under the various items.

Table 5.- Operating cost percentages

Item	Labor	Material	Total
Mining expense	52.90	18.91	71.81
Transportation	4.213	1.20	5.413
Ventilation	0.71	0.26	0.97
Tipple	3.84	0.22	4.06
Drainage	0.52	0.73	1.25
Dead work	2.27	0.17	2.44
Light, heat, power	1.23	0.89	2.12
Power purchased	-	4.443	4.443
Supervision	4.83	0.11	4.94
Office expense	1.54	0.29	1.83
Safety, hospital	0.01	0.004	0.014
Material handling charge	0.71	-	0.71
Total	72.77+	27.22+	100.00

Table 6 gives the classification of labor cost under the various items for the same period.

Table 6.- Classification of labor, per cent

Class of labor		Total
	Unit costs inside	
Shooting	5.59	
Track layers	5.84	
Cutting	15.43	
Timber	3.71	
Stonemen	14.06	
Gathering motors	11.28	
Loaders	16.79	72.70
	Inside daymen	
Mine foremen	1.13	
Assistant mine foremen	2.71	
Track layers	1.16	
Day laborers	3.53	
Bratticemen	0.56	
Wiremen	1.04	
Pumpers	0.30	
Trappers	0.14	
Supplymen	0.56	11.13
	Transportation	
Motormen	1.22	
Trip riders	0.81	
Dispatchers	0.67	2.70
	Outside men	
Foremen	0.76	
Clerks	1.28	
Laborers	1.53	
Electricians	0.40	
Blacksmiths	0.35	
Car repairmen	0.13	
Carpenters	0.27	
Tipple crew	5.05	
Machinists	0.36	
Watchmen	0.60	
Storeroom clerks	0.61	
Supplymen	0.41	11.75
Superintendence and engineering		1.72
Total		100.00

Units of Labor.- Table 7 gives the total tonnage produced during February, 1929, when the mine operated 22 full days on double shift, or a total of forty-four 8-hour shifts; also the number on each class of labor each shift, with the exception of 7 men on each shift known as the flying squadron, who fill the places of men absent in the units, and the servicing crew or mechanics. It also gives the average number of tons produced per shift, total shifts and man hours worked, tons per man employed on units and underground, and tons per man hour on units and underground.

Table 7.- Efficiency of production, when working 12 wide units, 6 narrow units, double shifts, each 22 full 8-hour shifts during February, 1929

Class of labor	Wide units Day shift	 Night shift	Narrow units Day shift	 Night shift	Total men Day shift	 Night shift	Total men both shifts	Total 8-hour shifts
Mechanical-loader runners	6	6	3	3	9	9	18	396
Mechanical-loader helpers	6	6	3	3	9	9	18	396
Cutting-machine runners	6	6	3	3	9	9	18	396
Cutting-machine helpers	6	6	3	3	9	9	18	396
Shot firers	6	6	3	3	9	9	18	396
Trackmen	6	6	3	3	9	9	18	396
Timbermen	6	6	-	-	6	6	12	264
Motormen	6	6	3	3	9	9	18	396
Trip riders	6	6	3	3	9	9	18	396
Stonemen	18	18	3	3	21	21	42	924
Total men on units	72	72	27	27	99	99	198	4,356
Maintenance crew	-	-	-	-	-	-	25	550
Foremen	-	-	-	-	2	2	4	88

Total 8-hour shifts	4,994
Total man hours	39,952
Coal produced, tons	44,083.45
Average coal per shift, tons	1,001.85
Average coal per shift per man employed on units, tons	10.12
Average coal per shift per man underground, tons	7.53
Coal per man hour on units, tons	1.2650
Coal per man hour all men employed underground, tons	1.103

SUMMARY

The findings of the investigation at this mine may be summarized as follows:

Mining Method.- The room-and-pillar panel method of mining as used at this mine is the general practice in eastern Ohio mines. No attepmt is made to recover pillars because of the treacherous nature of the immediate roof and the expected difficulty of controlling the bed of limestone 5 to 7 feet above the coal bed.

In practice it has been found that when rooms are worked out and allowed to cave adjacent to working places, little trouble is encountered with the immediate roof. This would imply that a method may be worked out to allow leaving larger pillars between rooms, and that a systematic method of pillar recovery on break lines 1,500 to 2,000 feet long could be made a successful operation; such a method would increase the total recovery of coal from 55 per cent at present to 95 per cent.

Cutting.- All cutting machines are double-shifted. During the period under consideration they averaged 111.32 tons of coal per shift. In addition, the cutters drilled all shot holes in the coal and slate. Greater efficiency may be obtained by using a 7-1/2-foot cutter bar in place of the 6-foot cutter bar now used.

Drilling and Blasting.- The drilling of shot holes is part of the cutters' duties and is paid for in the cutting rate. The shot holes are drilled with an unmounted electric drill, using an auger with only one cutting edge as shown in Figure 5. All shots are fired by a shot firer, who uses a small electric battery for the purpose. The shot firer also scrapes all the cutting from the kerf before shooting.

Loading.- The loading of coal mechanically at this mine is past the experimental stage, and for the past 15 months all coal has been loaded by machines. This is due to the efficiency of the unit system employed, where all members of the unit which load, cut, blast, and gather the coal are paid on a contract basis.

Timbering.- The adequacy of the method of posting used in rooms is assured by the good quality and the quantity of the posts and cap pieces furnished. On the entries, I-beams, 60-pound rail or wood crossbars with tight lagging are used; these are placed on small blocks in hitches resting on the top of the coal bed, thus eliminating the use of legs extending to the floor.

Transportation.- The transportation of the coal from the face to the tipple presents no unusual problems and is accomplished by the average means employed for a flat coal bed.

General Underground Conditions.- The general underground conditions of the mine are as good as may be found where a coal bed with a treacherous immediate roof is mined. Protection is afforded from falling slate on the entries and haulageways by tight lagging over the crossbars.

Permissible explosives fired electrically have been adopted for blasting purposes. But no rock-dust has been applied, and open-flame carbide lights are carried by all employees.

The power consumption is lower than one would expect in a complete mechanical operation; 3.57 kilowatt-hours of power was used during February, 1929, for each ton of coal produced.

Labor.- The wage payment on unit basis plan as worked out and applied at this property is filling a long-felt want in the coal industry, and may be successfully applied to a large number of other operations.

Efficiency of Operations.- The efficiency of operations is summarized in the following table:

Summary of Efficiency Data

Cutting machines, 9 shortwall double-shifted, average coal per shift, tons	111.32
Coal produced per pound of explosive, tons	4.88
Coal produced per linear foot of timber used, tons	0.7714
Coal produced per post used, tons	4.63
Average coal hauled by main locomotive per shift, tons	1,001.85
Average coal hauled by secondary locomotive per shift, tons	1,001.85
Total work performed on main and secondary haulage during February, 1929, ton-miles	147,143.55
Work on main and secondary haulage per ton of coal produced, ton-miles	3.3379
Average coal per gathering locomotive per shift, tons	111.32
Average coal per electric drill per shift, tons	111.32
Average number times each car is loaded per shift	1.53
Total power consumed in February, 1929, kilowatt-hours	158,228
Power consumed per ton of coal produced, kilowatt-hours	3.59
Coal per man employed underground, tons	7.95
Coal per man employed on units, tons	10.12
Coal per man hour underground, tons	0.9939
Coal per man hour on units, tons	1.2650
Mechanical loaders, 9 double-shifted, average tons per shift	111.32

Two specimen mine reports follow:

MINE REPORT

Unit No. 9 (narrow unit). Bad top (entry)

November 19, 1928.

	Minutes	Per cent	
Total available working time, minutes		950	
Coal loaded, tons		166	
Cars loaded		55	
Average coal per car, tons		3.02	
Average coal per move, tons		10.4	
Average coal per shift, tons		83	
TIME DISTRIBUTION:	Minutes	Per cent	
Loading	268.28	28.20	
Car changes	(68.66)		
Time used by loader on car changes	(11.45)		
Loader wait on car changes	57.21	6.03	
Shifting machine	66.53	7.01	**NECESSARY**
Move machine	87.10	9.18	
Oil machine	78.30	8.25	**63.70%**
Clean up	47.70	5.03	
No cars available	-	-	
No coal available	42.00	4.43	
Pick tight coal	30.20	3.37	
No power	1.55	0.16	
Blow cable	-	-	
Repair loader	19.36	2.04	**UNNECESSARY**
Repair track	20.00	2.11	
Smoke	21.60	2.27	**36.50%**
Remove falls on coal	25.82	2.72	
MOTOR DELAYS:			
Off track	43.70	4.60	
To passway	88.31	9.30	
Service stonemen	41.15	4.34	
Miscellaneous	11.00	1.16	
Total	949.81	100.20	
Average loading time per car, minutes		4.88	
Number of moves		16	
Average time per move, minutes		5.45	
Average distance per move, feet		350	
Average time per car change, minutes		1.75	

MINE REPORT

Total of reports on all wide-work units (6)
October 24, 1928.

Total available working time, minutes	10,939
Coal loaded, tons	2,921
Cars loaded	933
Average coal per car, tons	3.14
Average coal per move, tons	24
Average coal per shift, tons	129

TIME DISTRIBUTION:	Minutes	Per cent	
Loading	3,186.18	29.18	
Car changes	(1,259.45)		
Time used by loader on car changes	(264.75)		
Loader wait on car changes	994.70	9.10	
Shifting machine	1,256.52	11.50	
Move machine	1,377.16	12.64	NECESSARY
Oil machine	479.38	4.38	
Shoot coal	290.29	2.65	70.00%
Clean up	59.43	0.55	
No cars available	599.57	5.48	
No coal available	538.56	4.93	
Pick tight coal	257.37	2.35	
No power	200.76	1.83	
Blow cable	76.76	0.73	
Repair loader	453.10	4.15	
Repair track	88.58	0.82	UNNECESSARY
Unit motor delays	425.14	3.89	
Set post	43.76	0.40	29.99%
Remove falls on coal	389.20	3.56	
Smoke	111.46	1.02	
Miscellaneous	91.20	0.83	
	10,919.04	99.98	

Average loading time per car, minutes	3.41
Number of moves	122
Average time per move, minutes	11.03
Average time per car change, minutes	1.42
Average distance per move (loader), feet	250

CONDITIONS OF ROOMS:

Average width, feet	27.42
Average height of coal cut, inches	55.7
Depth of cut, feet	5.67

JOINT CONFERENCE OF REPRESENTATIVES OF EMPLOYEES

The mining employees are divided into six classes, as follows: Loading-machine operators, loading-machine helpers, cutters and drillers, transportation employees, maintenance employees, and outside employees.

The employees select their representative for the various departments by a secret ballot at an election held each six months. Two representatives are elected at each election, the retiring representatives being the two who receive the third lowest percentage of votes in the previous election.

The management selects six representatives. Meetings of employees and management representatives are held on the first Monday of each month to take up questions that arise in the various departments during the period, or if matters of importance need attention a special meeting is called. This plan has been in operation 15 months and has worked to the satisfaction of both employer and employee.

EMPLOYEES RELIEF ASSOCIATION AND INSURANCE PLAN

Each employee on being hired is interviewed in regard to supporting the Employees Relief Association and Insurance Plan. He is not compelled to join but readily does so after the plan is thoroughly explained. By joining the Employees Relief Association, for which the premium is 70 cents per month, the employee receives the following benefits: First, the company takes out and pays all premiums on a $500 life insurance policy as long as the employee keeps up his premium in the Relief Association; this policy is paid in full to his beneficiaries at his death, whether by natural or unnatural causes, while at work or otherwise. Second, he shall receive $10 per week after the first full week of disability for a period of 13 weeks in any one year for any sickness or accident that is not covered by State compensation. So far the employees have given 100 per cent support to this plan.

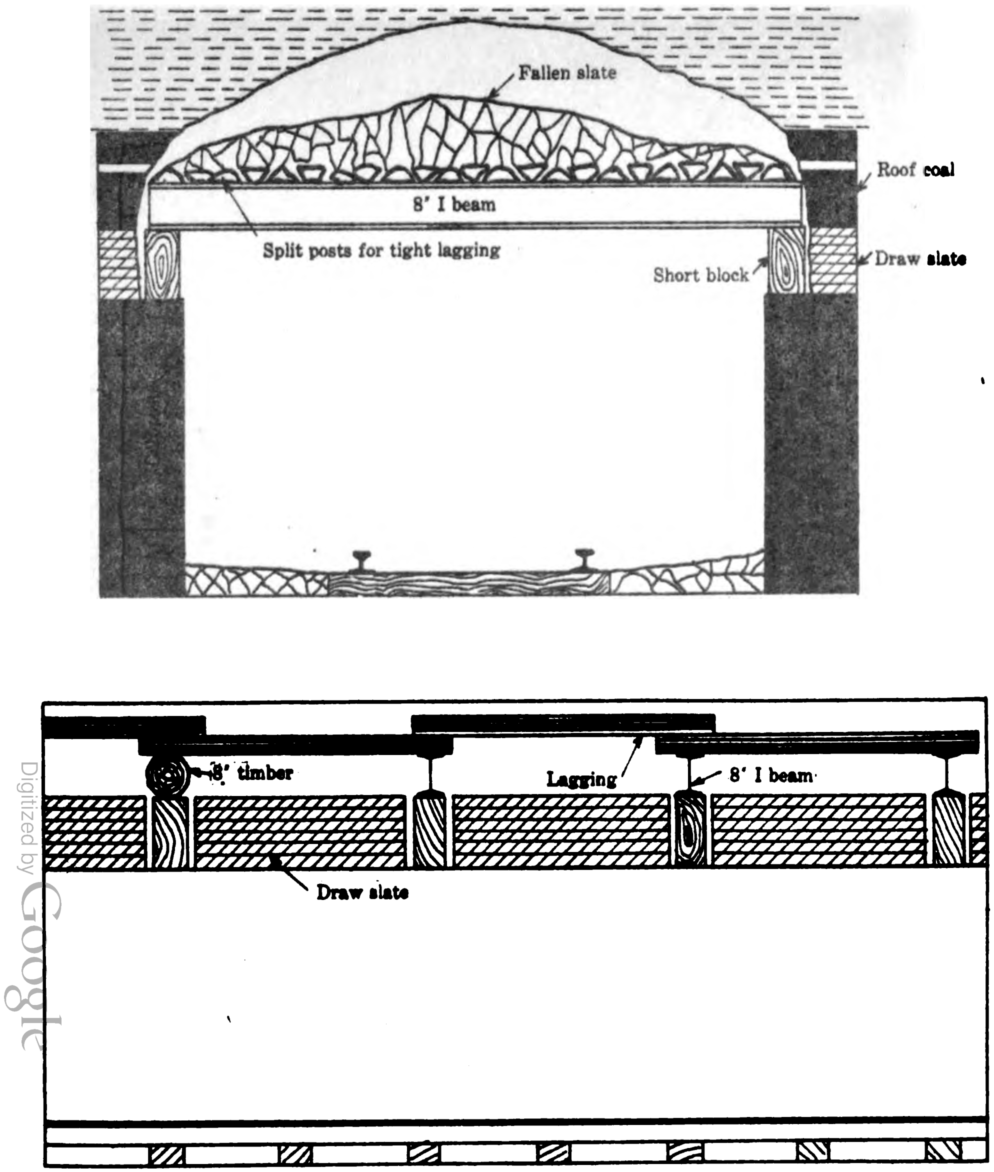


Figure 7.- Method of entry support used as protection from fallen rock

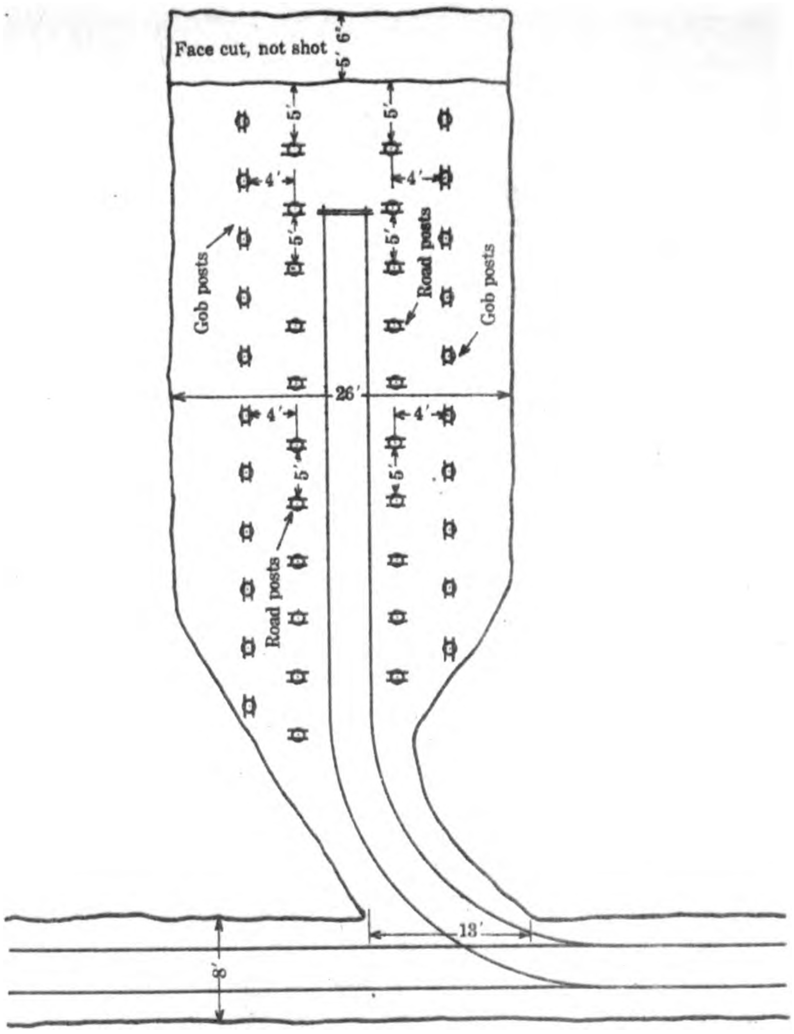


Figure 8.-Method of room posting